NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR VIIRS SEA ICE CONCENTRATION IP SOFTWARE (D42820 Rev A)

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Revision/Change Record

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---	5-6-05	Initial PCIM Release - Reference ECR A049	All
A1	6-20-06	11Oct05 - Reflects Raytheon-Omaha's Science To Operational Code Conversion 19Jan06 – Made minor edits to address 12Jan06 IPO CUTPR comments. 16Feb06 – Renumbering problem to fix Figure and Table references. Some got removed from original generic VIIRS-SeaIceCharacterization-IP-OAD (Pg 5 ref to Table 32, Pg 9 ref to Fig 16, Pg 10 ref to Fig 16-18, Pg 14 ref to Table 18 and 23 and 27 and Fig 19, Pg 17 ref to Table 32. 17May06 – Made minor edits to address 17May06 OPT CUT & CC PR comments. 20June06 – Final edits. 20June06 – Changed Document ID From D39593-IDP-002, to D41873 with approval from NGST DM	All
A2	5-17-07	Updated document for TM #: NP-EMD.2005.510.0038. Modified Section 2.2.3.1 added verbiage describing code changes for cross granule processing.	All
A3	6-22-07	Updates in response to SIC spl XGnl FO CCPR comments. – Change will to present tense where possible.	All
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A5	10-17-07	Renamed OAD from D41873 to D42820. Prepared for NGST delivery. Delivered to NGST for approval under ECR A-TBD.	All
A6	3-11-08	Updated document for TM# NP-EMD.2007.510.0046.	All
A7	6-9-08	Reformatted to conform to template document D41851. Updated graceful degradation and data quality monitoring sections	All
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A	12-10-08	Addressed TIM comments. Incorporates ECR A-182. Approved for Public Release per Contracts letter 090618-01.	All

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1.0 INTRODUCTION

1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system --- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:
1. Provide initial implementation design guidance to the operational software developer
2. Capture the "as-built" operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents.

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the VIIRS Sea Ice Concentration IP. The theoretical basis for this algorithm is described in Section 3.3 of the VIIRS Sea Ice Characterization Algorithm Theoretical Basis Document (ATBD), D41063.

1.3 References

1.3.1 Document References

The science and system engineering documents relevant to the algorithms described in this OAD are listed in Table 1.

Table 1. Reference Documents

Document Title	Document Number/Revision	Revision Date
VIIRS Ice Concentration Unit Level Detailed Design Document	Y3235 Ver.5 Rev. 5	21 Mar 2005
VIIRS Snow/Ice Module Interface Control Document	Y0011650 Ver. 5 Rev. 5	21 Mar 2005
VIIRS Snow/Ice Module Software Architecture Document	Y2477 Ver. 5 Rev. 6	21 Mar 2005
VIIRS Snow/Ice Module Data Dictionary	Y2482 Ver. 5 Rev. 5	21 Mar 2005
VIIRS Sea Ice Characterization Algorithm Theoretical Basis Document	D41063 Rev. E	14 Apr 2008
VIIRS Science Algorithms 3.4.5 Delivery to IDPS Package Version Description	D46567 Rev. ---	14 May 2008
NPP EDR Production Report	D37005 Rev. C	16 Mar 2007
EDR Interdependency Report	D36385 Rev. C	7 Nov 2007

Document Title	Document Number/Revision	Revision Date
NPP Mission Data Format Control Book (MDFCB)	GSFC 429-05-02-42 R1	14 Apr 2006
NPOESS Calibration/Validation Plan	D34484 Draft Version 3.0	17 Dec 2002
CDFCB-X Volume I - Overview	D34862-01 Rev. B	27 Aug 2007
CDFCB-X Volume II – RDR Formats	D34862-02 Rev. B	27 Aug 2007
CDFCB-X Volume III – SDR/TDR Formats	D34862-03 Rev. A	27 Aug 2007
CDFCB-X Volume IV Part 1 – IP/ARP/GEO Formats	D34862-04-01 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 2 – Atmospheric, Clouds, and Imagery EDRs	D34862-04-02 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 3 – Land and Ocean/Water EDRs	D34862-04-03 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 4 – Earth Radiation Budget EDRs	D34862-04-04 Rev. A	10 Sep 2007
CDFCB-X Volume V - Metadata	D34862-05 Rev. B	27 Aug 2007
CDFCB-X Volume VI – Ancillary Data, Auxiliary Data, Reports, and Messages	D34862-06 Rev. C	10 Sep 2007
CDFCB-X Volume VII – Application Packets	D34862-07 Rev. ---	10 Sep 2007
NPP Command and Telemetry (C&T) Handbook	568423 Rev. A	5 Apr 2005
NPOESS EDR Performance Report	NPOESS.02.520.010 Ver. 3.3	2 Feb 2002
Data Processor Inter-Subsystem Interface Control Document (DPIS ICD), D35850	D35850 Rev. U.2	27 Aug 2008
D35836_G_NPOESS_Glossary	D35836_G Rev. G	10 Sep 2008
D35838_G_NPOESS_Acronyms	D35838_G Rev. G	10 Sep 2008
Processing SI Common IO Design	DD60822-IDP-011 Rev. A	21 June 2007
NGST/SE technical memo –Cross-granule Processing Memo	NP-EMD.2005.510.0038	7 Mar 2005
NGST/SE technical memo – MS_Engineering_Memo_SeaIce_OAD_QualityFlag_Update	NP-EMD.2005.510.0137	14 Nov 2005
NGST/SE technical memo – MS_EngMemo_STIP_codefix_SPCR982_971	NP-EMD.2006.510.0004	3 Mar 2006
NGST/SE technical memo – NPP_VIIRS_STIP_QFUpdate_SCPR_ALG1010	NP-EMD.2006.510.0018	17 Mar 2006
NGST/SE technical memo – NPP_VIIRS_IceConc_logical_expression_fixes_067	NP-EMD.2006.510.0067	12 Sep 2006
NGST/SE technical memo – NPP_VIIRS_SeaIce_Concentration_STIP_Quality	NP-EMD.2006.510.0048	3 July 2006
NGST/SE technical memo – NPP_VIIRS_STIP_CodeQFUpdate_SPCR_ALG987	NP-EMD.2006.510.0059	27 Feb 2006
NGST/SE technical memo – NPP_VIIRS_IceConc_precision_fix	NP-EMD.2006.510.0072	18 Oct 2006
NGST/SE technical memo – NPP_VIIRS_SeaIce_v3.4.4_delta_delivery_OAD_updates	NP-EMD.2007.510.0046	8 Aug 2007
NGST/SE technical memo – NPP_VIIRS_SeaIce_v3.4.5_delta_delivery_OAD_updates	NP-EMD.2008.510.0018	14 Apr 2008

1.3.2 Source Code References

The science and operational code and associated documentation relevant to the algorithms described in this OAD are listed in Table 2.

Table 2. Source Code References

Reference Title	Reference Tag/Revision	Revision Date
VIIRS SeaIceConcentration Unit Test Data	ISTN_VIIRS_NGST_3.4.5 D41564 Rev. D	8 May 2008
VIIRS SeaIceConcentration science-grade software (original reference source)	ISTN_VIIRS_NGST_3.4.5 D46567 Rev. ---	14 May 2008
VIIRS SeaIceConcentration operational software	B1.5x1	24 Oct 2008

2.0 ALGORITHM OVERVIEW

The Sea Ice Concentration algorithm is the second executable in the Sea Ice Characterization chain. It utilizes VIIRS 375m Sensor Data Record (SDR) files, Intermediate Product (IP) files from the VIIRS Ice Quality algorithm, and two Sea Ice Look-Up-Table files as input to produce the Sea Ice Concentration IP files. The Ice Concentration processing chain is shown in Figure 1.

The Ice Concentration Unit generates two IP files:

- Ice Concentration IP
- Ice Reflectance & Temperature IP

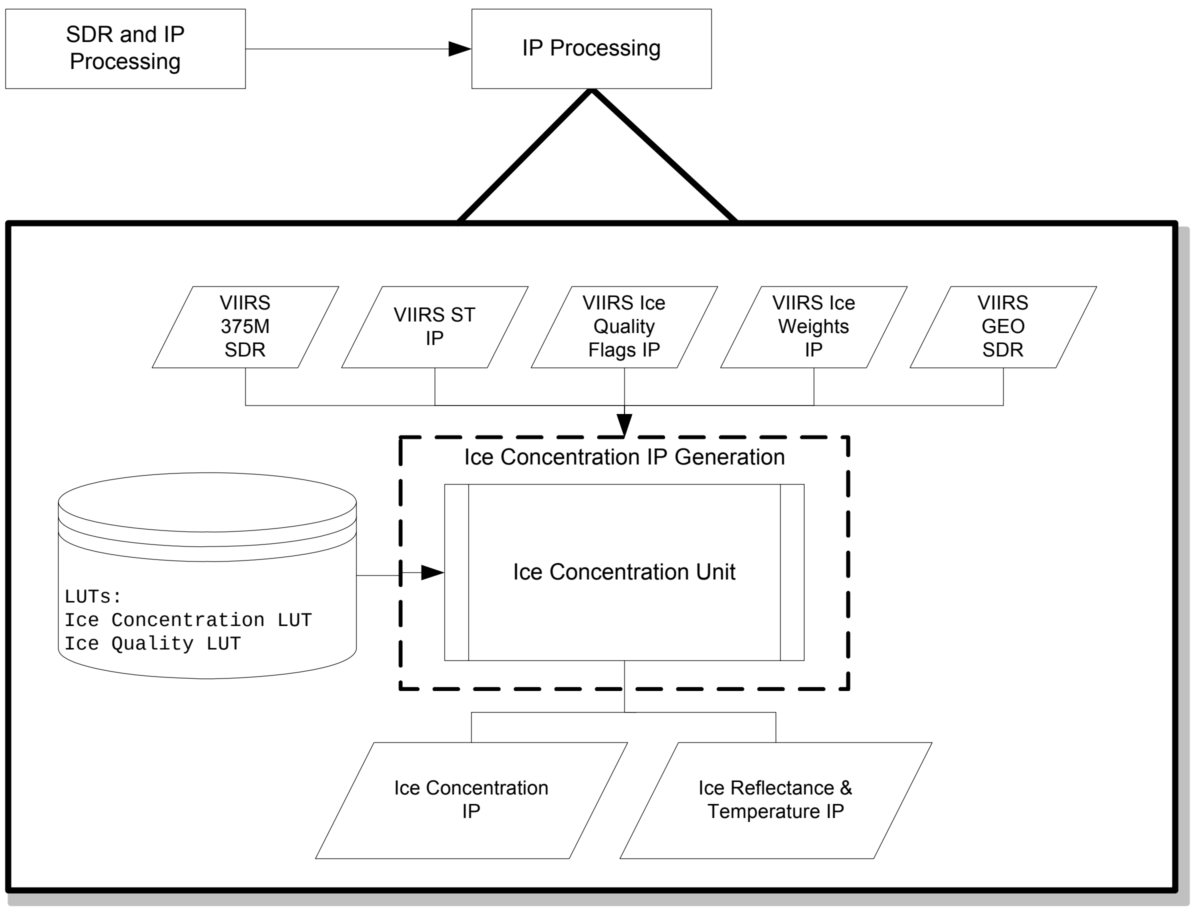

Figure 1. Ice Concentration Processing Chain

2.1 Sea Ice Concentration Intermediate Product Description

The Sea Ice Characterization EDR retrieval algorithm and the theoretical basis are described in detail in the VIIRS Sea Ice Characterization ATBD, D41603. That document also gives the theoretical basis for the Ice Concentration algorithm in Section 3.3.3.

2.1.1 Interfaces

Refer to the DPIS ICD, D35850, for a detailed description of the inputs.

2.1.1.1 Inputs

The Sea Ice Concentration Unit requires input files specified in Table 6. It should be noted that several practical considerations related to the VIIRS Surface Temperature IP (STIP) input are required and discussed in Section 4.1. A description of the contents of the STIP and details regarding the quality flags associated with it are described in the VIIRS Sea Ice Quality IP and Surface Temperature IP OAD. It should be noted that the value of the parameter max_wsize defined in Table 5 acts as a switch to allow the algorithm to be run using adjustable search window mode or with fixed sized search windows. The adjustable window mode should be the operational default run mode until the optimal window size is determined during Calibration/Validation. Table 3 shows the global attributes for Ice Concentration and Table 4 shows the main inputs for Ice Concentration.

Table 3. Global Attributes (Ice Concentration)

Input	Type	Description/Source	Units/Valid Range
VIIRS_RDR_SCANS	Int32	Number of RDR scans	Unitless/ VIIRS_RDR_SCANS > 0 ***(Currently set to 48)***
I_DETECTORS	Int32	Number of Image detectors	Unitless/ I_DETECTORS > 0 ***(Currently set to 32)***
I_VIIRS_SDR_ROWS	Int32	Number of image Viirs rows	Unitless/ VIIRS_RDR_SCANS * I_DETECTORS
I_VIIRS_SDR_COLS	Int32	Number of image Viirs columns	Unitless/ I_VIIRS_SDR_COLS > 0 ***(Currently set to 6400)***
IC_BANDS	Int32	Number of bands, extracted from the Ice Quality Flags IP, now represent band I1, I2, and surface temperature (not I5 brightness temperature values)	Unitless/ IC_BANDS > 0 ***(Currently set to 3 => I1,I2,STIP)***

Table 4. Main Inputs (Ice Concentration)

Input	Data Type/Size	Description/Source	Units/Valid Range
Reflectance_Img	float*32 x I_VIIRS_SDR_COLS X I_VIIRS_SDR_ROWS	I1 and I2 Reflectances, from the IMG SDR	Unitless/ Reflectance_Img > 0
Pixel Quality Img	Uint*8 x I_VIIRS_SDR_COLS X I_VIIRS_SDR_ROWS	I1 and I2 pixel level quality, from the IMG SDR	Unitless/ Pixel Quality Img ≥ 0
Actual Scans	Int*32	Number of scans in the granule, from the IMG Geolocation SDR	Unitless/ Actual Scans > 0
ST	float*32 x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Surface Temperature IP (STIP) @ Imagery resolution	Kelvin/ ST ≥ 0
ST Quality	Uint*8 x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Surface Temperature IP Quality Flags @ Imagery resolution	See Table 20 in the Sea Ice Quality IP and STIP OAD
Ice Weights	float*32 x IC_BANDS (I1,I2, STIP) x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Ice Weights for Imagery Bands (I1, I2) and STIP, from the Ice Weights IP	Unitless/ 0.0 ≤ Ice Weights ≤ 1.0
Sea Ice Range Flag	Uint*8	Granule not in sea ice range flag, from the Ice Quality IP	Unitless/ 0 = No 1 = Yes
Freshwater Ice Range Flag	Uint*8	Granule not in freshwater ice range flag, from the Ice Quality IP	Unitless/ 0 = No 1 = Yes

Input	Data Type/Size	Description/Source	Units/Valid Range
Ice Concentration LUT	See Table 5	See Table 5	See Table 5
Ice Quality LUT	See Ice Quality OAD	See Ice Quality OAD	See Ice Quality OAD

Table 5. Ice Concentration LUT

Input	Data Type/Size	Description/Source	Units/Valid Range
hmin	float*32 x IC_BANDS	Minimum range of histogram, by band. If hmin = hmax then code must derive hmin.	[Unitless, Kelvin]/ hmin = [0.0, 0.0, 0.0]
hmax	float*32 x IC_BANDS	Maximum range of histogram, by band. If hmax = hmin then code must derive hmax.	[Unitless, Kelvin]/ hmax = [0.0, 0.0, 0.0]
max_wsize	int*8	Maximum local window search size in pixels.	Unitless/ max_wsize ≥ 0 ***(Currently set to 15)***
min_pix_win	int*8	Minimum number of “good” ice pixels, in a search window, required for a reliable histogram	Unitless/ min_pix_win ≥ 0 ***(Currently set to 200)***
min_wsize	int*8	Minimum local window search size in pixels	Unitless/ min_wsize ≥ 0 ***(Currently set to 8)***
wat_wsize	int*8	Size of search window for local *water* tie points	Unitless/ wat_wsize ≥ 0 ***(Currently set to 15)***
min_pix_wat	int*8	Minimum number of “good” water pixels, in a search window, required for a reliable histogram	Unitless/ min_pix_wat ≥ 0 ***(Currently set to 50)***
nbig	int*8	Number of bins in the reflectance or temperature histograms (global)	Unitless/ nbig > 0 ***(Currently set to 100)***
nbin	int*8	Number of bins in the reflectance or temperature histograms (local)	Unitless/ nbin > 0 ***(Currently set to 50)***
ning	int*8	Number of bins for boxcar smoothing of global histograms	Unitless/ ning > 0 ***(Currently set to 5)***
nint	int*8	Number of bins for boxcar smoothing of local histograms	Unitless/ nint ≥ 0 ***(Currently set to 10)***
thre_def	float*32 x IC_BANDS	Default ice/water thresholds by band	[Unitless, Kelvin]/ thre_def = [0.2, 0.17, 269.0]
thre_max	float*32 x IC_BANDS	Maximum ice/water thresholds by band	[Unitless, Kelvin]/ thre_max = [0.25, 0.22, 270.0]
thre_min	float*32 x IC_BANDS	Minimum ice/water threshold by band	[Unitless, Kelvin]/ thre_min = [0.15, 0.13, 268.0]
wat_def	float*32 x IC_BANDS	Default water tie points	[Unitless, Kelvin]/ wat_def = [0.08, 0.07, 271.4]
wat_max	float*32 x IC_BANDS	Default maximum water tie point	[Unitless, Kelvin]/ wat_max = [0.1, 0.08, 278.0]
wat_min	float*32 x IC_BANDS	Default minimum water tie point	[Unitless, Kelvin]/ wat_min = [0.04, 0.03, 270.0]

Table 6. Ice Concentration IP Input File Specifications

Input	Object/Format	Original Source
VIIRS Earth View 375-meter I1 & I2 SDRs	IDPS Binary	VIIRS SDR Module
VIIRS 375-meter Geolocation SDR	IDPS Binary	VIIRS SDR Module
VIIRS Ice Weights IP	IDPS Binary	VIIRS Ice Quality IP Module
VIIRS Ice Quality Flags IP	IDPS Binary	VIIRS Ice Quality IP Module
VIIRS Surface Temperature IP	IDPS Binary	VIIRS Surface Temperature IP Module
Ice Concentration LUT	IDPS Binary	Lookup Table
Ice Quality LUT	IDPS Binary	Lookup Table

2.1.1.1.1 Requirements for Input

The Ice Concentration algorithm is reliant on VIIRS SDR and IP products. The processing approach developed for the Sea Ice Concentration algorithm is based on sliding windows that slide along the pixel row counting/averaging neighboring pixels surrounding each product pixel using these values as a basis for processing decisions. The sliding windows used by subroutines: IC_tie_point, IC_tie_point_plus and IC_local_water_tie_point include pixel information from both neighboring rows and neighboring columns. As a result, the first and last scan lines of the granule require that the pixel information from the preceding and succeeding granules be available. To accomplish this, the last scan of the previous granule and the first scan of the next granule is read and passed to the algorithm as extended data that gets processed along with the current granule.

2.1.1.2 Outputs

The Ice Concentration Unit produces outputs for two IP products:

- Ice Concentration IP
- Ice Reflectance & Temperature IP

The two IP files produced are “retained Cal/Val” IP files. Note: the Ice Concentration Application Related Product (ARP) described in the Sea Ice Characterization ATBD, D41063, is not required and is no longer generated as a product file by the code. The Ice Concentration ARP is therefore not described in this OAD.

Each of the retained IP files (Ice Concentration, Ice Reflectance and Temperature) contains parameters and attributes/metadata that are detailed in Table 7 through Table 9.

Table 7. Ice Reflectance & Ice Temperature IP

Output	Data Type/Size	Description	Units/Valid Range
IceTiePoints	float*32 x IC_BANDS x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Ice Tie Points computed for the two reflectance bands and the STIP	Kelvin/ IceTiePoints > 0.0 Unitless/ 0.0≤IceTiePoints≤1.0
SearchWinQual	int*8 x IC_BANDS x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Search Window Quality determined for the two reflectance bands and the STIP	Unitless/ SearchWinQual = 0 = Good Search Window 1 = Bad Search Window
LocalWaterTiePoints	float*32 x IC_BANDS x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Local Water Tie points computed for the two reflectance bands and the STIP	Kelvin/ LocalWaterTiePoints > 0.0 Unitless/ 0.0≤LocalWaterTiePoints≤1.0
WaterSearchWindowQual	int*8 x IC_BANDS x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Water Search Window Quality determined for the two reflectance bands and the STIP	Unitless/ SearchWinQual = 0 = Good Search Window 1 = Bad Search Window

Output	Data Type/Size	Description	Units/Valid Range
BandQual	int*8 x IC_BANDS x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Quality of the two reflectance bands and the STIP	Unitless/ BandQual = 0 = Green 1 = Red 2 = Yellow 4 = Water

Table 8. Ice Reflectance and Temperature IP Attributes/Metadata

Attribute	Data Type/Size	Description
GlobalWaterTiePoints	float*32 x IC_BANDS	Global Water Tie points for bands I1, I2, and Surface Temperature
IceWaterThreshold	float*32 x IC_BANDS	Ice Water Thresholds for bands I1, I2 and Surface Temperature

Table 9. Ice Concentration (Fraction) IP

Output	Data Type/Size	Description	Units/Valid Range
IceFraction	float*32 x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Ice Fraction	Unitless/ 0.0 ≤ IceFraction ≤ 1.0
ConcWgt	float*32 x I_VIIRS_SDR_COLS x I_VIIRS_SDR_ROWS	Ice Concentration Weights	Unitless/ 0.0 ≤ ConcWgt ≤ 1.0

2.1.2 Algorithm Processing

The Sea Ice Characterization EDR algorithm consists of four individual independent modules, which produce IP and EDR products. The arrow flows shown in Figure 2 below reflects the call sequence of the software units.

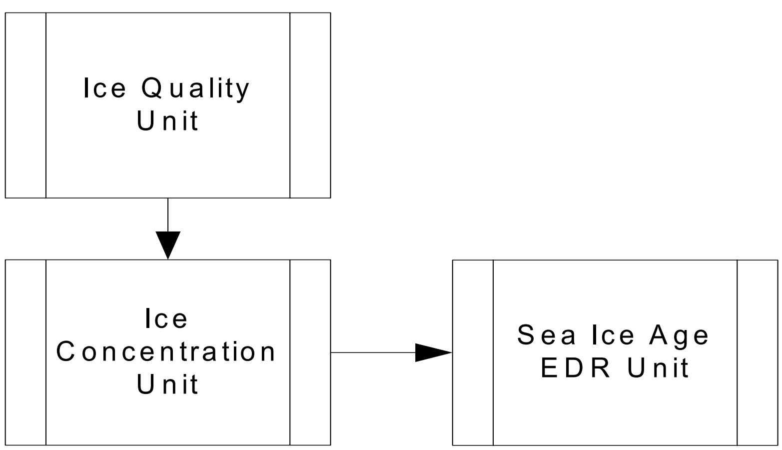

Figure 2. Call Sequence of the Sea Ice Characterization Algorithm Units

2.1.2.1 Main Module - Ice Concentration

This module reports ice concentration as a band weighted ice fraction for each imagery pixel. Module outputs are detailed in Section 2.1.1.2. The ice fraction is retrieved using a tie point method. Tie points, determined for ice and water pixels, are derived from the input reflectances (I1, I2) and surface temperature (ST) values, and are reported as reflectance values for I1 and

I2 and as temperature values for surface temperature. A top-level flow of this Ice Concentration module is shown in Figure 3.

The ice and water tie-points correspond to “peaks”, or histogram maximums, of Reflectance and Surface Temperature distributions over a single granule. These histograms are constructed using band specific parameters (I1, I2, and STIP values) and pre-determined LUT values that legislate histogram dimensions. To derive the ice/water tie-points, the algorithm must extrapolate from the band specific parameters histograms, the scene-specific ice/water threshold. The ice/water threshold corresponds to the local minimum of the band parameter distribution. For example, an ice/water threshold for the I1 reflectance band would correspond to a region of the parameter distribution that contains the least number of pixels. The histogram is “smoothed” out by using a running boxcar filter, producing a sliding integral of the parameter distribution. The boxcar filter window can either be fixed or self-adjusting. Each boxcar filter representing a portion of the histogram contains the summed up contribution of pixels within that region of the distribution. Each of these window filters are compared to other running filters within the histogram. The window containing the least number of pixels denotes the ice/water threshold region. The center of this region becomes the ice/water threshold point.

On either side of the threshold band specific water and ice tie points are computed for each imagery pixel. Water tie points are selected as maximums in a probability density distribution corresponding to the maximum of the sliding integral over water reflectance values (STIP). Ice tie points are derived locally for each imagery pixel for parameter values on the ice side of the ice/water threshold. For each pixel, the ice tie point is selected as the maximum value from a sliding integral over a localized parameter distribution. For more details on the tie point selection process refer to the Sea Ice Characterization ATBD, D41063, Section 3.3.3. Logic flow diagrams for the ice/water threshold and tie point determination are shown in Figures 4 through 6.

The tie point determination follows a similar algorithm as the ice/water threshold logic. For the case of local ice tie points, input data is filtered by the quality of the Ice Weights, computed in the Ice Quality IP module. An ice histogram is constructed and a running box filter produces a sliding integral, which “smoothes” out the distribution. Within a pre-determined local search window size a local maximum corresponds to a local ice tie point. Similarly, the water histogram is constructed from water pixels of good quality. The constructed distribution of water depends upon the tie point calculation in question. For global water tie points, the histogram makes use of all good quality water pixels. Local water tie points follow a similar localized search window recipe as the ice tie point computation. If there are not enough good pixels to compute a local water tie point, the local water tie point takes on the global water tie point as a default (see Table 10). Note: These tie point computations can implore a fixed or self-adjusting search window algorithm; the LUT parameters “max_wsize” and “min_wsize” determine which algorithm the Ice Concentration module utilizes. If max_wsize <= min_wsize, the self-adjusting algorithm is chosen.

Table 10. Ice Tie Point Logic Branches Not Shown in Flow Charts

Test	Logic	Result
Global tie point within LUT defined boundaries	IF (global_water_tie_point(band) < wat_min(band) || global_water_tie_point(band) > wat_max(band))	global_water_tie_point(band) = water_def(band)
Enough good water pixels in local search window	IF (not enough good water pixels in local search window)	local_water_ti_point(band) = global_water_tie_point(band)

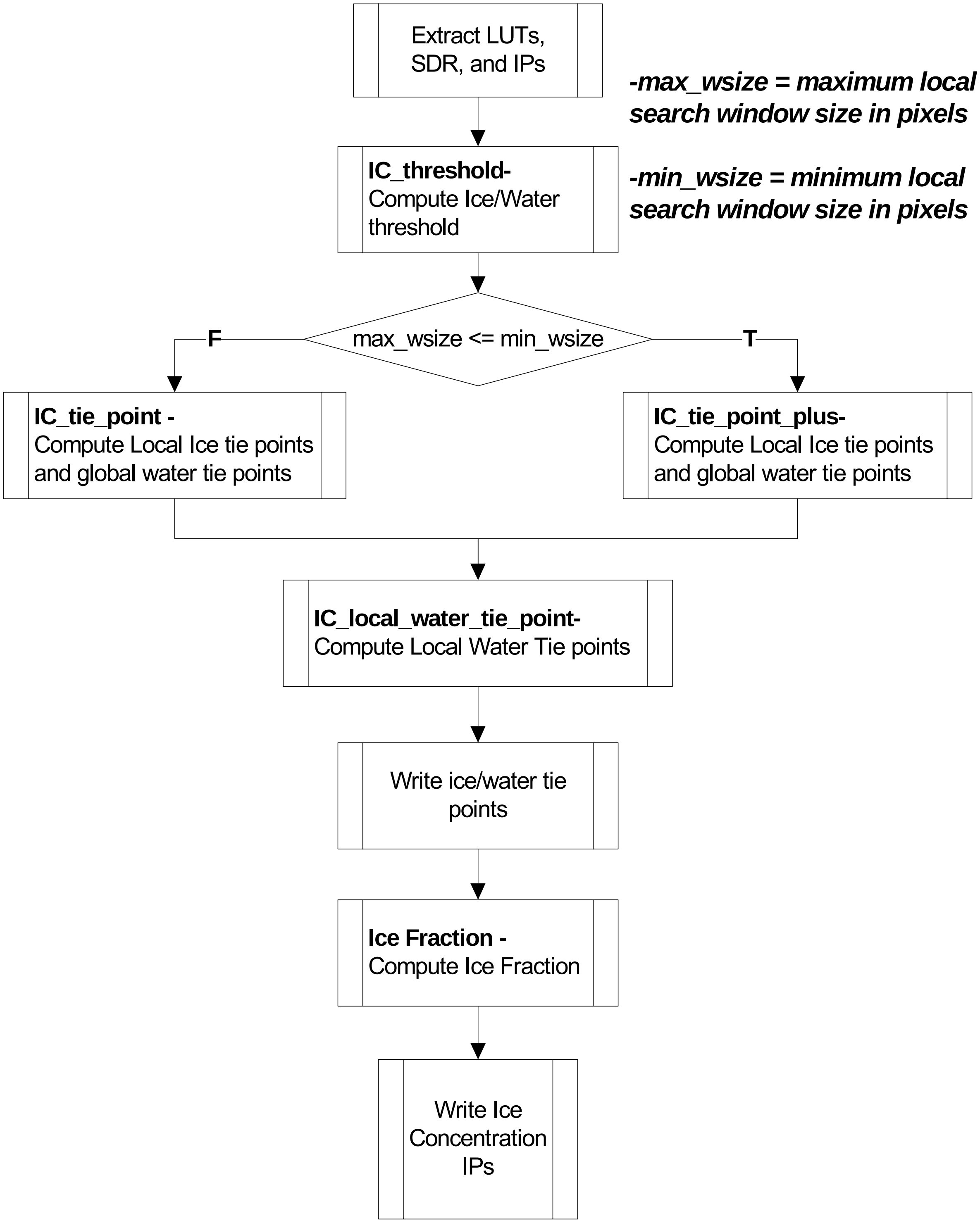

Figure 3. Ice Concentration Unit Top Level Flow

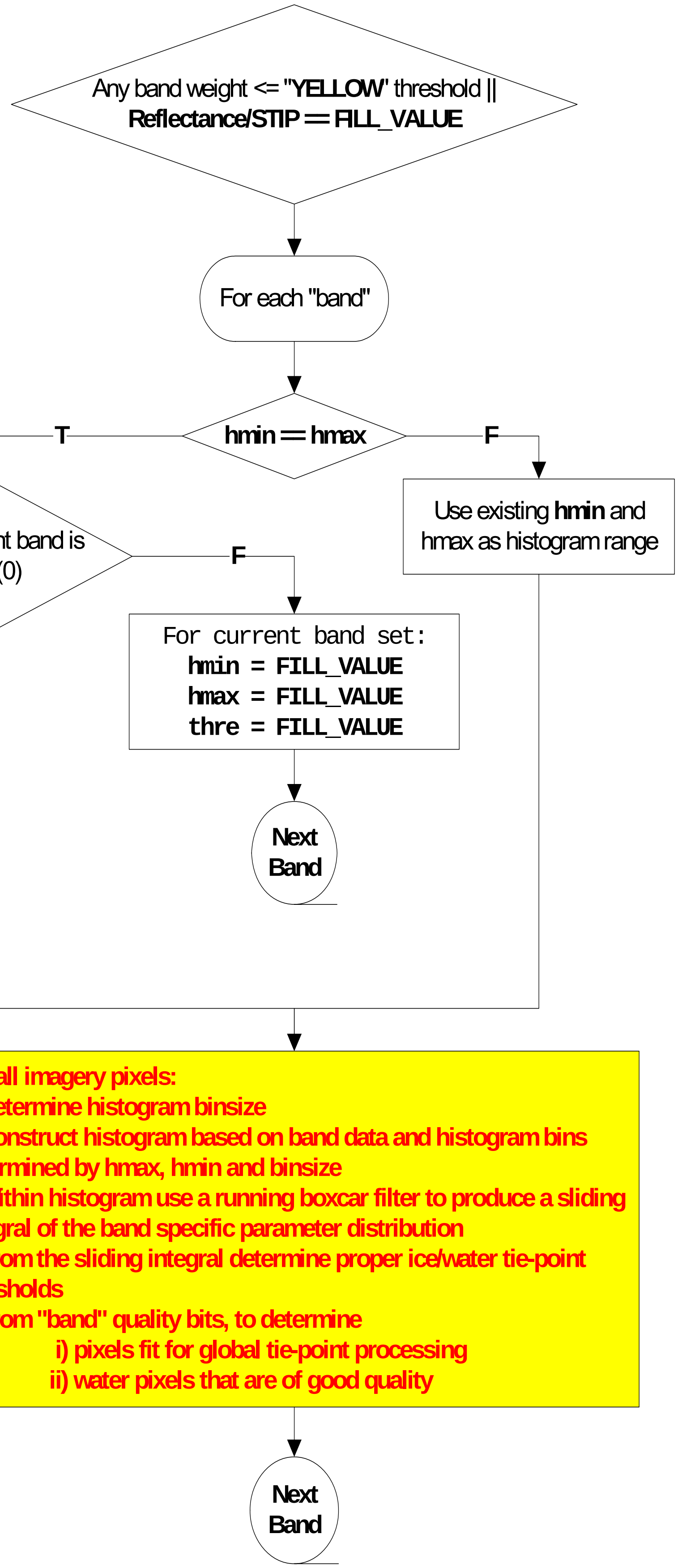

Figure 4. Logic Flow of `IC_threshold ()`

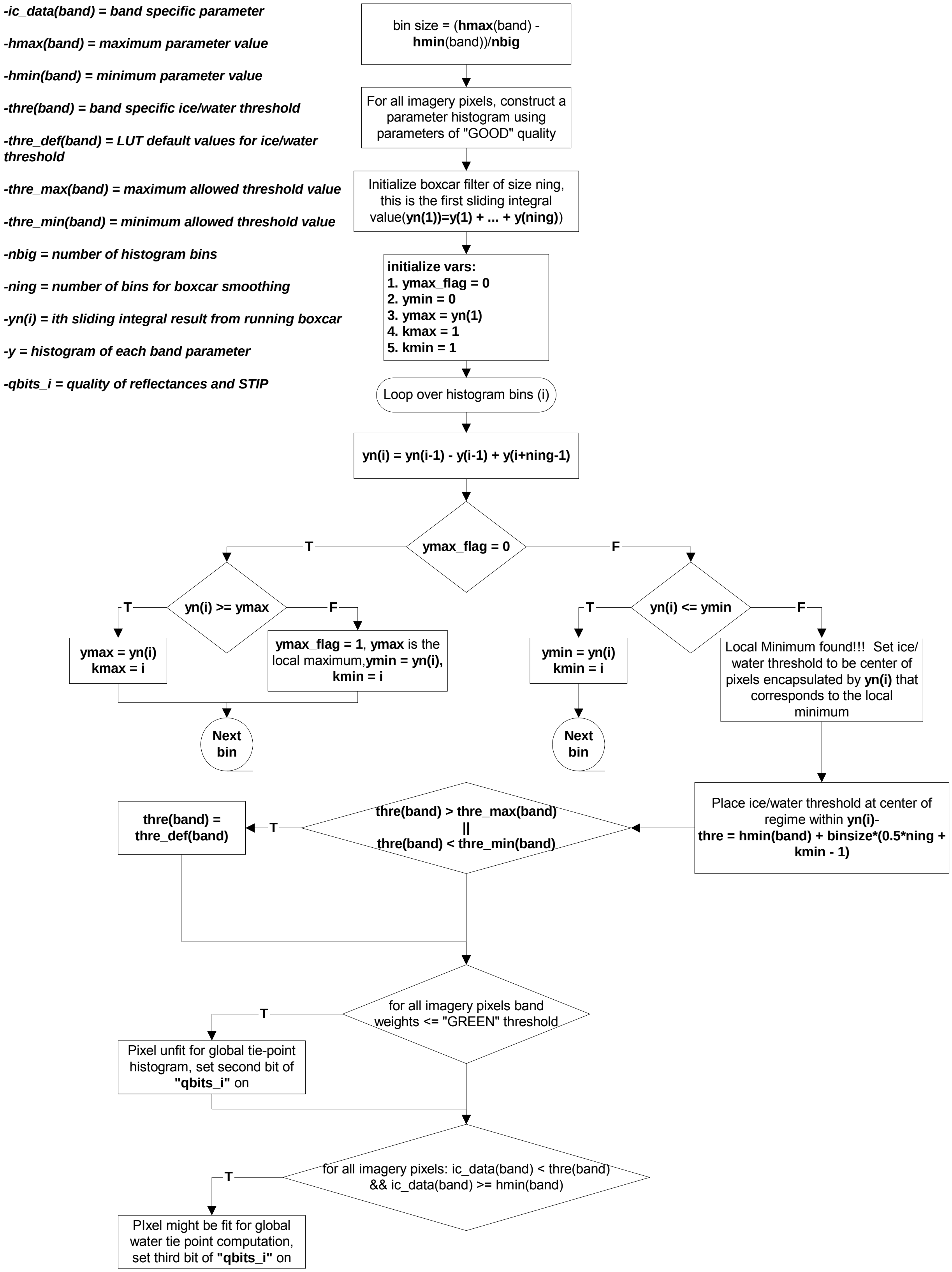

Figure 5. Detailed Diagram of Ice/Water Tie-Point Threshold Computation (`IC_threshold()`)

After tie points are computed, band specific ice concentration weights are computed from the tie points. These weights are derived from the Ice Weights IP. The algorithm then uses the band weights to compute an ice fraction for each imagery pixel (Figure 6). The ice fraction, along with the band weights, becomes the output of the Ice Concentration IP (Table 9).

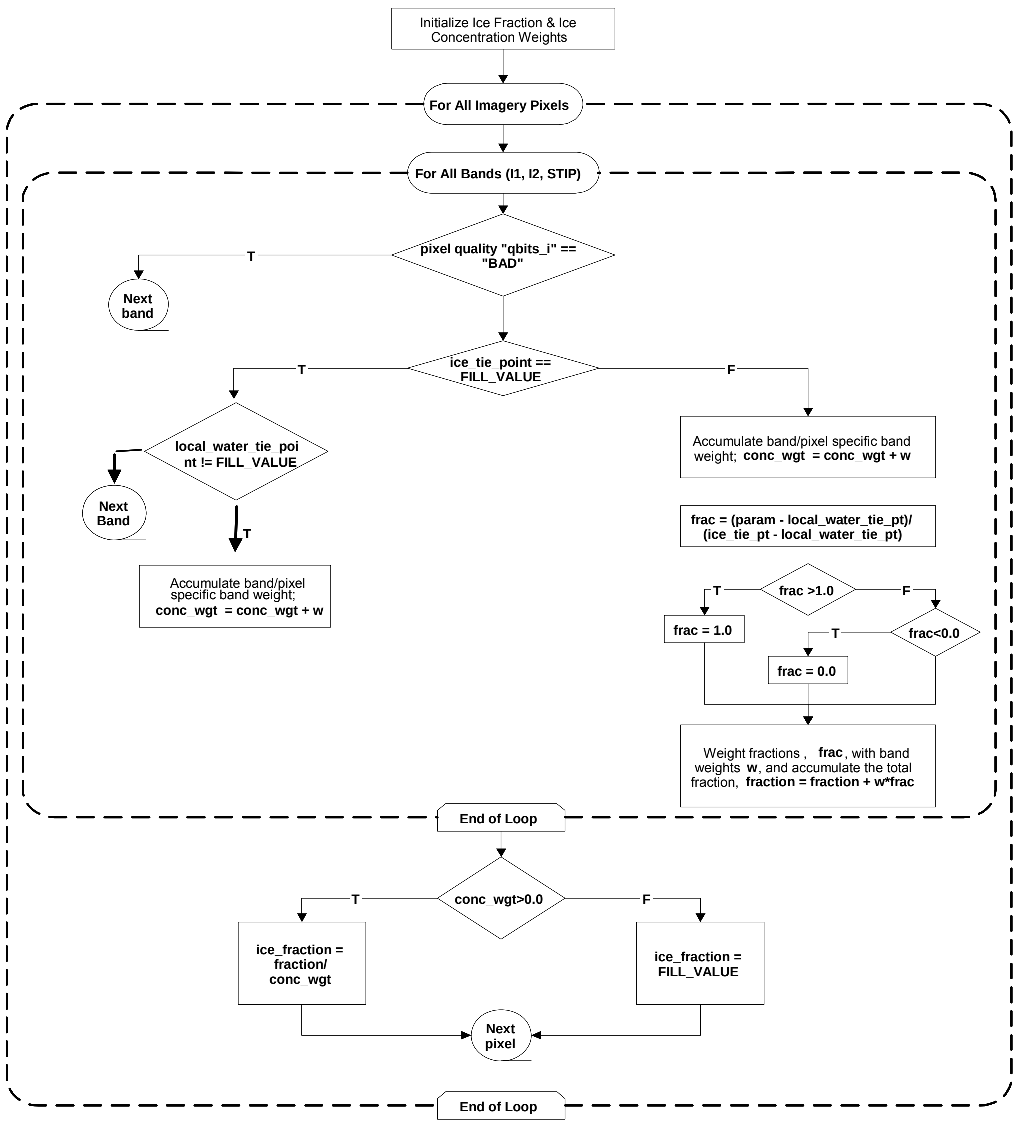

Figure 6. Ice Fraction Computation Logic (`IC_fraction()`)

2.1.3 Graceful Degradation

2.1.3.1 Graceful Degradation Inputs

There are two cases where graceful degradation in indicated in the Sea Ice Concentration IP.

1. The primary input denoted in the algorithm configuration guide cannot be successfully retrieved but an alternate input can be retrieved.

2. An input retrieved for the algorithm has its N_Graceful_Degradation metadata field set to YES (propogation).

Table 11 details the instances of these two cases for SIC. Note that the shaded cells indicate that the graceful degradation was done upstream at product production.

Table 11. SIC Graceful Degradation

Input Data Description	Baseline Data Source	Primary Backup Data Source	Secondary Backup Data Source	Tertiary Backup Data Source	Graceful Degradation Done Upstream
Sea Surface Wind Speed and Direction	VIIRS_GD_09.4.2 NCEP	VIIRS_GD_09.4.2 NCEP (Extended Forecast)	N/A	N/A	Yes
Adjusted Surface Pressure	VIIRS_GD_28.4.1 NCEP	VIIRS_GD_28.4.1 NCEP (Extended Forecast)	N/A	N/A	Yes
Surface Air Temperature	VIIRS_GD_09.4.10 NCEP	VIIRS_GD_09.4.10 NCEP (Extended Forecast)	N/A	N/A	Yes
Specific Humidity at Surface	VIIRS_GD_09.4.12 NCEP	VIIRS_GD_09.4.12 NCEP (Extended Forecast)	N/A	N/A	Yes
Aerosol Optical Thickness	VIIRS_GD_15.4.1 VIIRS AOT IP	VIIRS_GD_25.4.1 NAAPS	VIIRS_GD_15.4.1 Climatology	N/A	Yes, backup only.
Total Column Precipitable Water	VIIRS_GD_09.4.11 NCEP	VIIRS_GD_09.4.11 NCEP (Extended Forecast)	N/A	N/A	Yes
Total Column Ozone	VIIRS_GD_09.4.1 NCEP	VIIRS_GD_09.4.1 NCEP (Extended Forecast)	N/A	N/A	Yes

2.1.3.2 Graceful Degradation Processing

None.

2.1.3.3 Graceful Degradation Outputs

None.

2.1.4 Exception Handling

When processing granules outside the defined sea ice range, data fields in the output IPs are set to the “not applicable” (NA) fill value and the IPs are stored in DMS. When required input data is not available, the software logs the error(s) and exits gracefully. When processing night granules, the I1 and I2 band SDRs exist as empty shells, so only STIP data used during processing. Internal buffers representing the SDRs are set to fill values and skipped during processing. The code contains checks to insure “divide-by-zero” operations do not occur. If such a divide operation occurs, the software logs the error and exits gracefully.

2.1.5 Data Quality Monitoring

Each algorithm uses specific criteria contained in a Data Quality Threshold Table (DQTT) to determine when a Data Quality Notification (DQN) is produced. The DQTT contains the threshold used to trigger the DQN as well as the text contained in the DQN. If a threshold is met, the algorithm stores a DQN in DMS indicating the test(s) that failed and the value of the DQN attribute. For more algorithm specific detail refer to the CDFCB-X, D34862.

2.1.6 Computational Precision Requirements

Single precision 32-bit floating point computations are required.

2.1.7 Algorithm Support Considerations

The Sea Ice Concentration checks the one byte VIIRS Surface Temperature IP (STIP) retrieval quality flag word and performs retrievals for all pixels with STIP quality indicating non-fill. It should be noted that the value of the parameter max_wsize defined in Table 5 acts as a switch to allow the algorithm to be run using adjustable search window mode or with fixed sized search windows. A value of max_wsize = 0 will result in the algorithm running with a fixed search window size for computation of tie points. It is recommended that the algorithm be run using the adjustable search window mode until the optimal fixed window size is determined during calibration/validation .

Table 12 contains the tunable algorithm parameters that may need adjustment throughout the NPP and NPOESS program.

Table 12. List of Tunable Algorithm Parameters

Algorithm Parameter Name	Description	Parameter Location	Assigned Value
hmin	Minimum range of histogram, by band	Ice Concentration LUT	[0.0, 0.0, 0.0]
hmax	Maximum range of histogram, by band	Ice Concentration LUT	[0.0, 0.0, 0.0]
max_wsize	Maximum local window search size in pixels	Ice Concentration LUT	15
min_pix_win	Minimum number of “good” ice pixels, in a search window, required for a reliable histogram	Ice Concentration LUT	200
min_wsize	Minimum local window search size in pixels	Ice Concentration LUT	8
wat_wsize	Size of search window for local *water* tie points	Ice Concentration LUT	15
min_pix_wat	Minimum number of “good” water pixels, in a search window, required for a reliable histogram	Ice Concentration LUT	50
nbig	Number of bins in the reflectance or temperature histograms (global)	Ice Concentration LUT	100
nbin	Number of bins in the reflectance or temperature histograms (local)	Ice Concentration LUT	50
ning	Number of bins for boxcar smoothing of global histograms	Ice Concentration LUT	5
nint	Number of bins for boxcar smoothing of local histograms	Ice Concentration LUT	10
thre_def	Default ice/water thresholds by band	Ice Concentration LUT	[0.20,0.17,269.0]
thre_max	Maximum ice/water thresholds by band	Ice Concentration LUT	[0.25,0.22,270.0]
thre_min	Minimum ice/water threshold by band	Ice Concentration LUT	[0.15,0.13,268.0]
wat_def	Default water tie points	Ice Concentration LUT	[0.08,0.07,271.4]
wat_max	Default maximum water tie point	Ice Concentration LUT	[0.10,0.08,278.0]
wat_min	Default minimum water tie point	Ice Concentration LUT	[0.04,0.03,270.0]

2.1.8 Assumptions and Limitations

2.1.8.1 Assumptions

None

2.1.8.2 Limitations

None

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program, D35836_G_NPOESS_Glossary, can be found on eRooms. Table 13 contains those terms most applicable for this OAD.

Table 13. Glossary

Term	Description
Algorithm	A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of: 1. A theoretical description (i.e., science/mathematical basis) 2. A computer implementation description (i.e., method of solution) 3. A computer implementation (i.e., code)
Algorithm Configuration Control Board (ACCB)	Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT.
Algorithm Verification	Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.
Ancillary Data	Any data which is not produced by the NPOESS System, but which is acquired from external providers and used by the NPOESS system in the production of NPOESS data products.
Auxiliary Data	Auxiliary Data is defined as data, other than data included in the sensor application packets, which is produced internally by the NPOESS system, and used to produce the NPOESS deliverable data products.
EDR Algorithm	Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Environmental Data Record (EDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.). *[Supplementary Definition]* An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.
Model Validation	The process of determining the degree to which a model is an accurate representation of the real-world from the perspective of the intended uses of the model. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]
Model Verification	The process of determining that a model implementation accurately represents the developer's conceptual description and specifications. [Ref.: DoDD 5000.59-DoD Modeling and Simulation Management]
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.

Term	Description
Operational-Grade Software	Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code.
Raw Data Record (RDR)	*[IORD Definition]* Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data will be retained and communicated to the ground without lossy compression. *[Supplementary Definition]* A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.
Retrieval Algorithm	A science-based algorithm used to ‘retrieve’ a set of environmental/geophysical parameters (EDR) from calibrated and geolocated sensor data (SDR). Synonym for EDR processing.
Science Algorithm	The theoretical description and a corresponding software implementation needed to produce an NPP/NPOESS data product (TDR, SDR or EDR). The former is described in an ATBD. The latter is typically developed for a research setting and characterized as “science-grade”.
Science Algorithm Provider	Organization responsible for development and/or delivery of TDR/SDR or EDR algorithms associated with a given sensor.
Science-Grade Software	Code that produces data records in accordance with the science algorithm data quality requirements. This code, typically, has no software requirements for implementation language, targeted operating system, modularity, input and output data format or any other design discipline or assumed infrastructure.
SDR/TDR Algorithm	Scientific description and corresponding software and test data necessary to produce a Temperature Data Record and/or Sensor Data Record given a sensor’s Raw Data Record. The scientific computational basis for the production of each data record is described in an Algorithm Theoretical Basis Document (ATBD). At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Sensor Data Record (SDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data. *[Supplementary Definition]* A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.

Term	Description
Temperature Data Record (TDR)	*[IORD Definition]* Temperature Data Records (TDRs) are geolocated, antenna temperatures with all relevant calibration data counts and ephemeris data to revert from T-sub-a into counts. *[Supplementary Definition]* A Temperature Data Record (TDR) is the brightness temperature value measured by a microwave sensor, and the related information needed to access and understand the record. Specifically, it is a set of the corrected radiometric measurements made by an imaging microwave sensor, over a limited time range, with annotation that permits its effective use. A TDR is a partially-processed variant of an SDR. Instead of reporting the estimated microwave flux from a specified direction, it reports the observed antenna brightness temperature in that direction.

3.2 Acronyms

The current acronym list for the NPOESS program, D35838_G_NPOESS_Acronyms, can be found on eRooms. Table 14 contains those terms most applicable for this OAD.

Table 14. Acronyms

Acronym	Description
ACO	Atmospheric Correction over Ocean
AM&S	Algorithms, Models & Simulations
API	Application Programming Interfaces
ARP	Application Related Product
CDFCB-X	Common Data Format Control Book - External
CDR	Climate Data Records
CI	Configured Item
COT	Cloud Optical Thickness
DMS	Data Management Subsystem
DPIS ICD	Data Processor Inter-subsystem Interface Control Document
DQN	Data Quality Notification
IET	IDPS Epoch Time
IIS	Intelligence and Information Systems
INF	Infrastructure
ING	Ingest
IP	Intermediate Product
LUT	Look-Up Table
MDFCB	Mission Data Format Control Book
PRO	Processing
PW	Precipitable Water
QF	Quality Flag
RTM	Radiative Transfer Model
SDR	Sensor Data Records
SI	Software Item or International System of Units
SST	Sea Surface Temperature
ST	Surface Temperature
SWS	Surface Wind Speed
TBD	To Be Determined
TBR	To Be Resolved
TOA	Top of the Atmosphere
VCM	VIIRS Cloud Mask

4.0 OPEN ISSUES

Table 15. TBXs

TBD ID	Title/Description	Resolution Date
None		